



Development and psychometric evaluation of an experiential technology acceptance model instrument for virtual reality-based dark tourism in Malaysia

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Abstract

Virtual Reality (VR) provides new opportunities for tourism and heritage interpretation by enabling users to encounter digitally represented places, historical environments, and narratives through immersive interfaces. Evaluating the acceptance of VR in dark tourism, however, requires consideration of both functional technology perceptions and experiential responses appropriate to historically sensitive settings. This study developed and psychometrically evaluated a context specific instrument based on an experiential extension of the Technology Acceptance Model (TAM), referred to in this study as the Experiential Technology Acceptance Model (ETAM), for examining prospective acceptance of VR-based dark tourism among Malaysian domestic tourists. The framework integrates Perceived Usefulness (PU), Perceived Ease of Use (PEOU), Perceived Enjoyment (PE), Perceived Immersion (PI), and Behavioral Intention (BI). To maintain conceptual sensitivity to dark tourism, PE was operationalized as reflective satisfaction rather than entertainment derived from tragedy. The 20-item instrument was subjected to expert review and pilot testing involving 30 respondents before the main survey was administered. Following data screening, 272 valid responses were analyzed using Partial Least Squares Structural Equation Modeling (PLS SEM). The measurement model demonstrated strong indicator reliability, internal consistency, and convergent validity. However, elevated Heterotrait Monotrait Ratio values between PEOU and PE and particularly between PE and PI indicated that discriminant validity was not fully established across all construct pairs. The structural model explained 88.6% of the variance in PI and 78.1% of the variance in BI. PU significantly predicted BI, PEOU strongly predicted PU, and PE significantly predicted PI. The findings provide preliminary psychometric support for the instrument while identifying the need for further refinement, particularly in strengthening the empirical distinction between enjoyment and immersion.

Keywords: *experiential technology acceptance model, psychometric evaluation, perceived immersion, behavioral intention*

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1. Introduction

Virtual Reality (VR) has become increasingly relevant to tourism and heritage interpretation because it allows users to interact with digitally represented destinations and historical environments in ways that extend beyond conventional photographs, text panels, physical displays, and audiovisual presentations. VR can reconstruct environments that are physically inaccessible, altered, fragile, or no longer available and can present historical material through spatial and interactive experiences. Guttentag (2010) identified heritage preservation, education, accessibility, destination marketing, and visitor experience among the areas in which VR could contribute to tourism. Subsequent studies have continued to demonstrate the growing importance of immersive technology in tourism and cultural heritage environments (Bekele et al., 2018; Beck et al., 2019; Chang et al., 2025; Portugal et al., 2025; Imani et al., 2026; Lu et al., 2025).

The potential contribution of VR is particularly relevant to cultural heritage. Historical sites often communicate events for which physical remains are incomplete or where direct access may be constrained. Immersive technologies can supplement conventional interpretation by reconstructing historical environments, presenting contextual information, and enabling users to explore representations of places and events digitally. According to Bekele et al. (2018), augmented, virtual, and mixed reality technologies have been applied to cultural heritage reconstruction, education, exploration, exhibition enhancement, and virtual museums. These applications indicate that immersive technology can broaden the mechanisms through which heritage information is communicated.

Research on tourism related VR further determines that immersive environments influence more than technological interaction alone. For example, Huang et al. (2016) extended Technology Acceptance Model (TAM) within a virtual tourism setting by integrating psychological and experiential dimensions, which evidenced that the interpretation of virtual tourism technologies requires attention to both functional acceptance and the nature of the experience itself. Similarly, Tussyadiah et al. (2018) showed that presence within VR tourism experiences can influence enjoyment, destination attitudes, and subsequent visitation intentions.

These issues become particularly sensitive in dark tourism. Dark tourism encompasses visitation to places associated with death, warfare, disaster, suffering, tragedy, and other difficult dimensions of the past (Korstanje, 2026; Tripathi & Bansal, 2025; Magano et al.,

2022). According to Light (2017), research in this field intersects with heritage, remembrance, interpretation, motivation, identity, and cultural memory. Consequently, immersive technologies used within dark tourism should not be evaluated solely according to entertainment value. Their role should also be considered in relation to respectful interpretation, historical understanding, education, remembrance, and reflection.

Malaysia provides an appropriate setting for examining these issues because the country contains memorial landscapes and historical places connected with war, disaster, conflict, and difficult heritage. Sabah, for example, contains locations closely associated with the Sandakan Death Marches and the experiences of prisoners of war during the Second World War. Research within the wider Southeast Asian context also illustrates the interpretive complexities associated with war heritage. Muzaini et al. (2007), through their examination of Fort Siloso in Singapore, presented tensions between experiential presentation, visitor engagement, and the interpretation of difficult historical narratives. Such concerns reinforce the importance of balancing immersive presentation with historical sensitivity.

Understanding whether potential visitors would accept VR for such purposes requires an appropriate technology acceptance framework. The TAM developed by Davis (1989) remains a foundational framework for explaining technology adoption. TAM identifies Perceived Usefulness (PU) and Perceived Ease of Use (PEOU) as central perceptions associated with users' acceptance of technology. Venkatesh and Davis (2000) subsequently extended TAM and further demonstrated the importance of PU in explaining technology usage intentions. The continued relevance of TAM within contemporary hospitality and tourism technologies is also evident in recent research. Dominguez et al. (2026) examined guests' acceptance of digitalized hotel booking systems through PU and PEOU, which strengthen the continuing relevance of these constructs when evaluating technology acceptance within hospitality and tourism contexts.

Traditional TAM, however, was primarily developed within utilitarian information system settings. Immersive VR involves experiential processes extending beyond functional usefulness and usability. The acceptance of hedonic information systems can involve perceived enjoyment (PE) as an important determinant (Van der Heijden, 2004), which also emphasizes psychological presence and the subjective sensation of being situated within a virtual environment (Slater, 2009). Within tourism, presence plays an important role in VR-based visitor experience and subsequent behavioral responses (Wei et al., 2019).

Accordingly, the present study adopts an experiential extension of TAM. For the purposes of this study, this integrated framework is referred to as the Experiential Technology Acceptance Model (ETAM). ETAM is not presented as a replacement for TAM or as an independently established universal theory. Instead, it represents the context specific framework operationalized in this study by combining the functional TAM dimensions of PU and PEOU with PE and PI. PE requires particular conceptual care in dark tourism. Conventional enjoyment measures can imply pleasure, amusement, or entertainment. Such interpretations may be inappropriate when the content concerns death, war, disaster, and human suffering. Therefore, PE is retained as the construct label for consistency with technology acceptance literature but is operationalized in this study as reflective satisfaction. Reflective satisfaction represents interest, meaningful engagement, personal reward, and reflection arising when immersive heritage interpretation contributes to historical understanding. It does not refer to enjoyment of tragedy itself.

The present study therefore develops and psychometrically evaluates a 20-item instrument for examining Malaysian domestic tourists' prospective acceptance of VR-based dark tourism. Rather than claiming complete instrument validation, the study evaluates indicator reliability, internal consistency, convergent validity, discriminant validity, and structural relationships among PU, PEOU, PE, PI, and Behavioral Intention (BI). This positioning enables the strengths and remaining measurement limitations of the instrument to be reported transparently.

2. Literature Review

2.1 Technology Acceptance in Tourism Technologies

TAM, developed by Davis (1989), explains users' acceptance or rejection of technological systems through two fundamental beliefs: PU and PEOU. PU refers to the extent to which individuals believe that using a technology will improve the performance or value of an activity, whereas PEOU refers to the extent to which they perceive that operating the technology requires relatively little effort. Venkatesh and Davis (2000) extended TAM by examining additional determinants of PU and BI, reinforcing the importance of usefulness and the relationships among users' perceptions of a technological system.

TAM has been widely applied to tourism and hospitality technologies, including virtual tourism and immersive digital experiences. Huang et al. (2016) integrated TAM with

psychological factors to examine user responses within a three-dimensional virtual tourism environment and found that technology acceptance involves both technological perceptions and experiential characteristics. Similarly, Yan et al. (2024) found that PEOU positively influences PU, while both constructs contribute to users' attitudes and BI toward adopting online tourism experiences. Chen et al. (2025) further demonstrated that PU and PEOU positively influence tourists' intentions to visit physical destinations following virtual tourism experiences. In the context of metaverse tourism, Jiang (2025) integrated TAM with the Theory of Planned Behavior and found that PU and PEOU significantly influence tourists' attitudes, subjective norms, perceived behavioral control, and BI, with PEOU exhibiting a stronger direct effect on BI.

Recent studies further support the applicability of TAM to digital tourism environments. Dominguez et al. (2026) found that perceived system quality was strongly associated with PU and PEOU in guests' acceptance of digitalized hotel booking systems. Although digital booking differs from immersive virtual reality (VR), there is continuing relevance of TAM-based perceptions in hospitality and tourism technology adoption. Ma et al. (2026), integrating TAM with the Stimulus–Organism–Response and Technology Readiness frameworks, found that PEOU enhances PU and intention to use virtual tourism modules, which subsequently increases tourists' intention to visit physical destinations. Similarly, Mihos and Kokkinis (2026) reported that PU, PEOU, trust and security, and facilitating conditions positively influence BI to adopt digital technologies in tourism.

Perceived Usefulness. In the context of dark tourism, PU refers to the extent to which respondents believe that VR can improve their understanding and interpretation of dark tourism destinations. Its relevance extends beyond functional efficiency to include educational and interpretive benefits. Guttentag (2010) identified education, accessibility, and heritage preservation as areas in which VR can provide value to tourism. Accordingly, VR may be perceived as useful when it clarifies historical narratives, provides access to otherwise difficult-to-experience environments, communicates historical information effectively, and supports meaningful interpretation of sensitive heritage. This perspective positions usefulness as a functional and educational evaluation of VR rather than merely its capacity to facilitate technological interaction.

Perceived Ease of Use. PEOU represents respondents' perceptions of whether VR applications are understandable and manageable to operate. As a fundamental TAM construct,

it is closely associated with PU (Davis, 1989; Venkatesh & Davis, 2000). This relationship has also been demonstrated in tourism contexts, where PEOU contributes to PU and BI toward adopting digitally mediated tourism experiences (Yan et al., 2024; Chen et al., 2025; Jiang, 2025; Ma et al., 2026).

Ease of use is particularly relevant to immersive VR because complex controls, navigation, or technical requirements may divert users' attention from the content being experienced. In dark tourism environments, this distraction may reduce the cognitive resources available for understanding historical events and interpreting sensitive heritage narratives. Conversely, intuitive interaction may allow users to focus more fully on the educational and interpretive value of the virtual environment. Therefore, PEOU is expected to contribute to respondents' evaluations of VR's usefulness for exploring dark tourism destinations.

Perceived Enjoyment. PE requires careful conceptualization when applied to dark tourism because encounters with death, suffering, tragedy, and collective remembrance involve ethical and interpretive considerations. Light (2017) emphasized the complex relationships among death, remembrance, heritage, motivation, ethics, and interpretation in dark tourism. Consequently, measuring enjoyment solely in terms of entertainment or amusement may be inappropriate when evaluating VR experiences involving tragic historical events. To address this concern, the present study conceptualizes PE as reflective satisfaction, referring to positive experiential responses arising from an experience that is meaningful, interesting, engaging, or personally rewarding. This conceptualization does not imply pleasure derived from death or suffering; rather, it emphasizes the satisfaction associated with engaging meaningfully with historical narratives and heritage environments. Accordingly, the measurement items use expressions such as personally rewarding, reflective satisfaction, interesting, and engaging rather than language that suggests amusement derived from tragedy.

The relevance of enjoyment in immersive tourism experiences is supported by Tussyadiah et al. (2018), who demonstrated a relationship between presence and enjoyment in VR tourism, and Wei et al. (2019), who identified enjoyment as one of the experiential factors associated with presence. However, reflective satisfaction and immersion remain conceptually distinct: the former concerns users' positive evaluations of the experience, whereas the latter concerns their psychological absorption in the virtual environment. Their empirical distinctiveness is therefore an important psychometric consideration in the present study.

Perceived Immersion. PI represents the extent to which users anticipate becoming psychologically absorbed in a virtual environment. According to Slater (2009), immersive virtual environments can generate a subjective sensation of being situated in a simulated place, even when users consciously recognize that the environment is artificial. In tourism research, stronger presence in VR was associated with enjoyment and favorable destination responses (Tussyadiah et al., 2018) while presence contributes positively to visitor experiences and subsequent behavioral responses (Wei et al., 2019).

Within dark tourism, immersion may facilitate historical interpretation by allowing users to relate abstract information to spatial and contextual representations of historical environments. Through a stronger sense of presence, users may better understand the setting in which historical events occurred and engage more meaningfully with associated narratives. Nevertheless, immersion should serve educational and interpretive purposes rather than transform tragic events into spectacle. Although PI and PE may be related in VR experiences, they represent different dimensions of users' responses and should be examined as distinct constructs.

Behavioral Intention. BI represents respondents' prospective willingness to use VR applications to explore dark tourism destinations and recommend such applications to others. Within TAM, BI is a key outcome of technology acceptance perceptions, particularly PU and PEOU (Davis, 1989; Venkatesh & Davis, 2000). Tourism research further indicates that behavioral responses are associated with both technological evaluations and experiential characteristics. According to Huang et al. (2016), there is a relationship between technology-related perceptions and user responses in virtual tourism, in which VR presence can influence attitudes and subsequent visitation intentions (Tussyadiah et al., 2018).

According to Yan et al. (2024), PU and PEOU are linked to attitudes and BI toward online tourism experiences. These constructs positively influence tourists' intentions to visit physical destinations after virtual tourism experiences (Chen et al., 2025). Jiang (2025) likewise established their relevance to BI toward metaverse tourism, supporting the argument that technology acceptance perceptions can contribute to intentions to use virtual tourism modules and subsequently visit physical destinations (Ma et al., 2026).

Building on these theoretical and empirical foundations, the present study examines whether functional perceptions, represented by PU and PEOU, and experiential perceptions, represented by PE as Reflective Satisfaction and PI, contribute to respondents' BI to use VR

for exploring dark tourism destinations. This approach extends the application of TAM by incorporating experiential dimensions relevant to immersive heritage encounters while maintaining sensitivity to the educational, historical, and ethical characteristics of dark tourism.

2.2 Experiential Technology Acceptance Model

The ETAM used in the present study represents a context specific extension of TAM for immersive tourism experiences. The framework retains PU and Perceived Ease of Use while incorporating PE and PI as experiential dimensions. This approach is consistent with tourism technology research that adapts technology acceptance frameworks according to the characteristics of particular digital environments. For example, Tom Dieck and Jung (2018) developed a theoretical model of mobile augmented reality acceptance within urban heritage tourism that illustrates the value of contextualizing technology acceptance frameworks within heritage environments.

PE represents the intrinsic experiential response associated with interacting with technology. According to Van der Heijden (2004), enjoyment can play an important role in the acceptance of systems whose value is partly experiential rather than purely instrumental. Virtual tourism experiences contain psychological and experiential dimensions that extend traditional acceptance models (Huang et al., 2016). On the other hand, PI refers to psychological absorption in a virtual environment. Immersive environments can generate a subjective sensation of being located within a simulated place (Slater, 2009), which a stronger sense of presence in VR contributes to enjoyment and more favorable attitudes toward represented destinations (Tussyadiah et al., 2018). Multiple characteristics of VR experiences contribute to users' sense of presence and that presence can influence overall experience, revisit intention, and recommendation intention (Wei et al., 2019).

2.3 Dark Tourism and Digital Heritage

Dark tourism research extends beyond conventional tourism consumption. There is a close relationship between dark tourism, heritage tourism, remembrance, interpretation, motivation, and cultural memory (Light, 2017). Sites associated with tragedy may consequently carry educational, commemorative, historical, and social responsibilities. VR potentially offers additional mechanisms for supporting these responsibilities. According to

Guttentag (2010), education, accessibility, and heritage preservation are among the potential tourism applications of VR. Immersive technologies are useful for cultural heritage reconstruction, education, exploration, and exhibition (Bekele et al., 2018). However, immersive presentation should not automatically be regarded as improved heritage interpretation. The experiential presentation of war heritage can involve tensions between visitor engagement and the interpretation of difficult history (Muzaini et al., 2007). Consequently, immersive heritage initiatives should be evaluated not only according to technological sophistication but also according to historical integrity, sensitivity, and interpretive purpose. Against this background, the present instrument examines how potential users perceive both functional and experiential dimensions of VR based dark tourism.

3. Methodology

3.1 Research Design

The study adopted quantitative, cross sectional research design and positivist orientation. A deductive approach was used because the measurement constructs and structural relationships were informed by established technology acceptance and immersive experience literature. A standardized questionnaire was used to measure PU, PEOU, PE, PI, and BI. Quantitative measurement was appropriate because the constructs were operationalized as latent variables represented by multiple reflective indicators (Creswell & Creswell, 2018).

3.2 Population and Sampling

The target population comprised Malaysian domestic tourists aged 18 years and above. Direct prior experience with VR was not required because the study examined prospective acceptance of a clearly described VR dark tourism scenario rather than post use evaluation of a standardized operational VR system. A non-probability sampling approach incorporating purposive and quota considerations was employed. The approach enabled respondents with different demographic and geographical characteristics to participate while ensuring that basic inclusion criteria were met. Because probability sampling was not employed, the findings should not be interpreted as statistically representative of the entire population of Malaysian domestic tourists.

3.3 Contextual VR Scenario

Before answering the measurement items, respondents were presented with a contextual description of a VR-based dark tourism experience. The scenario described the use of a commercial VR headset to explore a three-dimensional digital reconstruction of a Malaysian historical memorial environment. The described experience included 360-degree viewing, spatial movement, historical information, audio narration, and digital representations of a heritage environment. The scenario provided respondents with a common frame of reference before they evaluated the questionnaire statements. The scenario emphasized historical interpretation and educational engagement rather than entertainment. This distinction was particularly important because PE was operationalized as reflective satisfaction. Consequently, the findings represent prospective perceptions and BI toward the described VR experience. They should not be interpreted as post use evaluations obtained after respondents experienced an identical operational VR application.

3.4 Instrument Development

The instrument consisted of 20 reflective indicators representing five constructs. PU contained four items, PEOU contained four items, PE contained four items, PI contained five items, and BI contained three items. The conceptual development of the instrument was informed by established literature on technology acceptance, experiential information systems, virtual environments, and tourism. Core supporting literature included Davis (1989), Venkatesh and Davis (2000), van der Heijden (2004), Guttentag (2010), Huang et al. (2016), Light (2017), tom Dieck and Jung (2018), Tussyadiah et al. (2018), Beck et al. (2019), and Wei et al. (2019). The cited studies are treated as theoretical and contextual sources supporting instrument development. The study does not claim that every final measurement item was reproduced verbatim from a single existing published scale. Responses were recorded using a five-point Likert scale ranging from 1, Strongly Disagree, to 5, Strongly Agree.

3.5 Expert Review and Pilot Assessment

Before the main survey, the instrument was reviewed by an expert panel consisting of three academics with relevant knowledge of heritage tourism and one specialist familiar with immersive technology. The review considered conceptual relevance, item clarity, contextual appropriateness, and suitability of the wording. The instrument was subsequently pilot tested

with 30 respondents. Cronbach's Alpha was calculated as an initial assessment of internal consistency.

Table 1

Initial reliability assessment of the pilot instrument (n = 30)

Latent Construct	Code	Number of Items	Cronbach's Alpha (α)
Perceived Usefulness	PU	4	0.953
Perceived Ease of Use	PEOU	4	0.975
Perceived Enjoyment	PE	4	0.973
Perceived Immersion	PI	5	0.974
Behavioral Intention	BI	3	0.959

All five constructs demonstrated high internal consistency during the pilot assessment. Cronbach's Alpha ranged from 0.953 to 0.975. However, coefficients of this magnitude may also indicate closely related item content. The pilot results were therefore treated as evidence of strong preliminary internal consistency rather than confirmation of complete psychometric validity.

3.6 Measurement Items

Table 2

Measurement scale items, codes, and supporting literature

Construct	Code	Measurement Item	Supporting Literature
Perceived Usefulness	PU1	Using VR would help me better understand dark tourism sites.	Davis (1989); Guttentag (2010); Huang et al. (2016)
	PU2	VR applications would make learning about historical tragedies more effective.	Davis (1989); Guttentag (2010); Huang et al. (2016)
	PU3	Using VR would enhance my overall interpretation of memorial environments.	Davis (1989); Guttentag (2010)
	PU4	I would find VR technology useful for exploring sensitive heritage narratives.	Davis (1989); Guttentag (2010)
Perceived Ease of Use	PEOU1	Learning to operate VR dark tourism applications would be easy for me.	Davis (1989); Venkatesh and Davis (2000); tom Dieck and Jung (2018)
	PEOU2	I would find it simple to get VR applications to do what I want them to do.	Davis (1989); Venkatesh and Davis (2000)
	PEOU3	My interaction with VR heritage applications would be clear and understandable.	Davis (1989); Venkatesh and Davis (2000)
	PEOU4	It would be effortless for me to become skillful at using VR applications.	Davis (1989); Venkatesh and Davis (2000)
Perceived Enjoyment	PE1	I would find navigating a VR dark tourism experience personally rewarding.	van der Heijden (2004); Huang et al. (2016); Light (2017)

Construct	Code	Measurement Item	Supporting Literature
	PE2	Using VR to explore historical sites would provide me with reflective satisfaction.	van der Heijden (2004); Light (2017)
	PE3	I would find the process of interacting with VR heritage applications interesting.	van der Heijden (2004); Huang et al. (2016)
	PE4	Using VR for dark tourism exploration would be an engaging experience.	van der Heijden (2004); Tussyadiah et al. (2018)
	PI1	I would feel as though I am physically present at the site when using VR.	Slater (2009); Tussyadiah et al. (2018); Wei et al. (2019)
	PI2	The VR experience would make me feel deeply absorbed in the historic narrative.	Slater (2009); Wei et al. (2019)
Perceived Immersion	PI3	I would lose track of time while exploring dark tourism sites through VR.	Slater (2009); Wei et al. (2019)
	PI4	The virtual environment would feel highly realistic and immediate to me.	Slater (2009); Tussyadiah et al. (2018)
	PI5	I would feel emotionally connected to the virtual representation of the site.	Tussyadiah et al. (2018); Wei et al. (2019)
Behavioral Intention	BI1	I intend to use VR to explore dark tourism destinations in the future.	Davis (1989); Venkatesh and Davis (2000); Huang et al. (2016)
	BI2	I predict that I would use VR media to experience regional heritage sites.	Davis (1989); Venkatesh and Davis (2000)
	BI3	I would recommend using VR dark tourism experiences to other travelers.	Wei et al. (2019)

Note. The references in the final column provide theoretical and contextual support for the constructs and development of the item wording. They do not indicate that every measurement item was reproduced verbatim from the cited source.

3.7 Data Screening and Final Sample

A total of 342 survey responses were initially collected. One response was excluded because participant consent was not provided. A further 69 responses were excluded following data screening because of unvaried or straight-lined response patterns and the applied screening criteria. The final audited dataset therefore contained 272 valid responses. No missing values remained in the final dataset.

3.8 PLS SEM Analysis

The final dataset was analyzed using SmartPLS 4. Partial Least Squares Structural Equation Modeling was employed because the analysis involved multiple latent constructs, measurement evaluation, prediction, and direct and indirect structural relationships (Hair et al., 2022). The analysis proceeded in two stages. The reflective measurement model was first assessed using outer loadings, Cronbach's Alpha, Composite Reliability, Average Variance Extracted, and the Heterotrait Monotrait Ratio. The structural model was then assessed using

path coefficients, explanatory power, and statistical significance. Bootstrapping with 5,000 resamples was applied to evaluate the statistical significance of the structural relationships.

4. Results

4.1 Reflective Measurement Model Assessment

All 20 indicators recorded outer loadings exceeding 0.70. The observed loadings ranged from 0.923 to 0.976, supporting indicator reliability. Cronbach's Alpha ranged from 0.950 to 0.978, while Composite Reliability ranged from 0.964 to 0.984. These results demonstrate high internal consistency. However, the magnitude of these coefficients also warrants caution because extremely high internal consistency can indicate highly similar item content.

Average Variance Extracted ranged from 0.870 to 0.937. All values exceeded the conventional threshold of 0.50, providing support for convergent validity.

Table 3

Measurement model reliability and convergent validity

Construct	Item	Outer Loading	Cronbach's Alpha	Composite Reliability	AVE
Behavioral Intention	BI1	0.949	0.964	0.974	0.903
	BI2	0.954			
	BI3	0.947			
Perceived Ease of Use	PEOU1	0.972	0.978	0.984	0.937
	PEOU2	0.966			
	PEOU3	0.966			
	PEOU4	0.967			
Perceived Enjoyment	PE1	0.950	0.963	0.973	0.902
	PE2	0.950			
	PE3	0.948			
	PE4	0.951			
Perceived Immersion	PI1	0.953	0.970	0.978	0.917
	PI2	0.971			
	PI3	0.937			
	PI4	0.976			
	PI5	0.951			
Perceived Usefulness	PU1	0.935	0.950	0.964	0.870
	PU2	0.923			
	PU3	0.937			
	PU4	0.936			

4.2 Discriminant Validity Assessment

Discriminant validity was evaluated using the Heterotrait Monotrait Ratio. Most construct pairs recorded values below 0.90. However, the relationship between PEOU and PE produced an HTMT value of 0.925, while the relationship between PE and PI produced an HTMT value of 0.953.

Table 4

Heterotrait monotrait ratio assessment

Construct	BI	PEOU	PE	PI	PU
BI					
PEOU	0.805				
PE	0.883	0.925			
PI	0.892	0.894	0.953		
PU	0.834	0.854	0.851	0.896	

The results do not support a claim that discriminant validity was fully established across all five constructs. In particular, the HTMT value of 0.953 between PE and PI indicates substantial empirical overlap. The value of 0.925 between PEOU and PE also exceeds the commonly applied 0.90 criterion. The constructs were retained because they represent theoretically different dimensions. Nevertheless, the results identify an important limitation of the current instrument. Consequently, the study is positioned as a psychometric evaluation rather than definitive scale validation.

4.3 Structural Model Assessment

Table 5

Structural path analysis and hypothesis testing results

Effect	Hypothesis	Relationship	β	Standard Error	t Value	p Value	Decision
Direct	H1	PU $\rightarrow$ BI	0.212	0.082	2.589	0.010	Supported
Direct	H2	PEOU $\rightarrow$ PU	0.824	0.029	28.233	< 0.001	Supported
Direct	H3	PE $\rightarrow$ BI	0.337	0.222	1.519	0.129	Not Supported
Direct	H4	PI $\rightarrow$ BI	0.392	0.225	1.739	0.082	Not Supported
Direct	H5	PEOU $\rightarrow$ PI	0.074	0.138	0.537	0.591	Not Supported
Direct	H6	PE $\rightarrow$ PI	0.603	0.143	4.218	< 0.001	Supported
Indirect	H7a	PEOU $\rightarrow$ BI	0.285	0.111	2.569	0.010	Supported
Indirect	H7b	PE $\rightarrow$ BI	0.237	0.181	1.308	0.191	Not Supported
Indirect	H7c	PU $\rightarrow$ BI	0.121	0.069	1.768	0.077	Not Supported

Note: Statistical significance was evaluated at $p < 0.05$.

The structural model explained 88.6% of the variance in PI ($R^2 = 0.886$) and 78.1% of the variance in BI ($R^2 = 0.781$). The structural relationships were assessed through bootstrapping using 5,000 resamples.

4.4 Interpretation of Structural Relationships

PU demonstrated a statistically significant positive relationship with BI ($\beta = 0.212$, $t = 2.589$, $p = 0.010$), supporting H1. Respondents who perceived VR as useful for understanding and interpreting dark tourism experiences therefore demonstrated stronger prospective intentions to use the technology.

PEOU demonstrated a strong statistically significant relationship with PU ($\beta = 0.824$, $t = 28.233$, $p < 0.001$), supporting H2. This finding indicates that perceptions of usability are strongly associated with whether respondents consider VR useful.

PE did not demonstrate a statistically significant direct relationship with BI ($\beta = 0.337$, $t = 1.519$, $p = 0.129$). H3 was therefore not supported.

PI also did not demonstrate a statistically significant direct relationship with BI at the $p < 0.05$ level ($\beta = 0.392$, $t = 1.739$, $p = 0.082$). H4 was therefore not supported.

PEOU did not significantly predict PI ($\beta = 0.074$, $t = 0.537$, $p = 0.591$), and H5 was not supported.

PE demonstrated a statistically significant positive relationship with PI ($\beta = 0.603$, $t = 4.218$, $p < 0.001$), supporting H6. Respondents who anticipated the VR experience as meaningful, interesting, engaging, and personally rewarding were more likely to anticipate stronger immersion.

For the indirect effects, the relationship reported between PEOU and BI was statistically significant ($\beta = 0.285$, $t = 2.569$, $p = 0.010$), supporting H7a. The reported indirect relationships between PE and BI ($\beta = 0.237$, $t = 1.308$, $p = 0.191$) and PU and BI ($\beta = 0.121$, $t = 1.768$, $p = 0.077$) were not statistically significant. H7b and H7c were therefore not supported.

The indirect coefficients are reported according to the SmartPLS results generated from the specified structural model. No additional mediation mechanism beyond the analyzed paths is inferred from these coefficients.

5. Discussion

The purpose of this study was to develop and psychometrically evaluate an experiential technology acceptance instrument for examining prospective acceptance of VR-based dark tourism in Malaysia. The findings demonstrate several strong psychometric characteristics while simultaneously identifying unresolved issues concerning construct distinctiveness. The measurement model produced high indicator loadings across all five constructs. Cronbach's Alpha and Composite Reliability also demonstrated strong internal consistency, while AVE values provided evidence of convergent validity. These results should nevertheless be interpreted carefully. Internal consistency values approaching or exceeding 0.95 can indicate that indicators are highly similar. Consequently, the high reliability coefficients should not automatically be interpreted as evidence that the instrument is psychometrically complete. Subsequent studies should examine whether selected indicators can be refined or removed while maintaining adequate construct coverage.

The discriminant validity findings represent the most important measurement limitation. HTMT values of 0.925 between PEOU and PE and 0.953 between PE and PI exceeded the commonly applied 0.90 criterion. Therefore, the present findings do not justify a claim of complete discriminant validity. The relationship between PE and PI deserves particular attention. Reflective satisfaction and psychological immersion are theoretically distinguishable, but respondents may have experienced difficulty differentiating meaningful engagement from psychological absorption when evaluating a prospective VR experience. Future psychometric development should therefore focus on strengthening this conceptual separation.

At the structural level, PU significantly predicted BI. This result is consistent with TAM, which emphasizes the importance of PU in explaining technology acceptance (Davis, 1989; Venkatesh & Davis, 2000). It is also broadly consistent with technology acceptance research within hospitality and tourism, where usefulness remains an important dimension of users' acceptance of digital systems (Dominguez et al., 2026). Within the context of dark tourism, the finding suggests that users may be more likely to adopt VR when they perceive clear interpretive or educational value. Technological novelty alone may therefore be insufficient to encourage prospective adoption.

PEOU demonstrated the strongest significant structural relationship through its association with PU. This finding indicates that users may be more likely to recognize the

usefulness of VR when it appears accessible and manageable. Complex technological interaction could undermine perceived value by diverting attention from historical interpretation. PE, conceptualized as reflective satisfaction, significantly predicted PI. This result supports the inclusion of experiential processes within the framework. VR tourism research has similarly demonstrated relationships between presence, enjoyment, and visitor responses (Tussyadiah et al., 2018; Wei et al., 2019). However, neither PE nor PI independently predicted BI at the $p < 0.05$ level. This pattern suggests that experiential characteristics may contribute to anticipated experience quality without necessarily serving as the principal drivers of prospective adoption intention.

These structural findings should be interpreted in light of the elevated HTMT value between PE and PI. Because complete empirical separation between the two constructs was not achieved, conclusions regarding their distinct structural roles should remain provisional pending further refinement and independent replication. Nevertheless, the instrument demonstrates promising psychometric characteristics but requires further development before full construct distinctiveness can be established.

6. Theoretical Implications

The study contributes to technology acceptance and immersive tourism research in several ways.

First, it reinforces the continuing relevance of traditional TAM constructs within immersive environments. PU significantly predicted BI, while PEOU strongly predicted PU. Functional technology perceptions therefore remained important even within a technology characterized by immersive and experiential features.

Second, the study demonstrates how technology acceptance models can be adapted to specific tourism environments. Previous research has extended TAM within virtual tourism and heritage technologies (Huang et al., 2016; tom Dieck & Jung, 2018). The present study extends this reasoning into the sensitive context of dark tourism.

Third, the study contextualizes PE as reflective satisfaction. This distinction allows positive experiential responses to be evaluated without implying that users derive entertainment from death, tragedy, or suffering.

Fourth, the results demonstrate that conceptual differentiation does not automatically guarantee empirical differentiation. Although PE and PI represent theoretically distinct

concepts, the HTMT results indicate substantial overlap between them. This finding provides a clear direction for further psychometric development.

Finally, the findings suggest that functional and experiential perceptions may operate differently within the model. PE contributed significantly to PI, while PU directly predicted BI. Reflective satisfaction may contribute more strongly to anticipated experiential absorption, whereas usefulness may play a more direct role in prospective adoption.

7. Practical Implications

The findings provide several implications for heritage managers, tourism administrators, and developers considering VR based interpretation of sensitive historical environments.

First, VR applications should provide clear interpretive and educational value. The significant relationship between PU and BI indicates that users need to recognize meaningful benefits from the technology.

Second, technological usability should remain a priority. PEOU strongly predicted PU, indicating that complex interaction may reduce the extent to which users perceive the system as valuable.

Third, immersive and engaging design remains important because PE significantly contributed to PI. However, immersion should support historical interpretation rather than become an objective in itself.

Fourth, dark tourism technology should maintain historical accuracy, dignity, and sensitivity. Immersive design should strengthen access to historical narratives without trivializing the suffering represented by the site. Consequently, technological sophistication should remain subordinate to interpretive purpose, usability, historical integrity, and respectful storytelling.

8. Limitations and Future Research

Several limitations should be considered when interpreting the findings.

First, non-probability sampling limits the statistical generalizability of the findings to the entire population of Malaysian domestic tourists.

Second, respondents evaluated a contextual description of a VR experience rather than completing the instrument immediately after standardized exposure to the same operational VR application. The findings therefore represent prospective acceptance and anticipated experience rather than actual post use behavior. Future research should evaluate the instrument following standardized exposure to an operational VR environment.

Third, the high internal consistency values indicate that some indicators may contain overlapping content. Future psychometric studies should examine item redundancy and determine whether a more parsimonious version can maintain adequate reliability and construct coverage.

Fourth, discriminant validity was not fully established. The HTMT value of 0.953 between PE and PI indicates substantial empirical overlap, while the value of 0.925 between PEOU and PE also exceeds the commonly used 0.90 criterion. Future research should revise selected items, conduct cognitive interviews, compare alternative measurement specifications, and retest the instrument using an independent sample.

Fifth, the instrument was developed within the Malaysian domestic tourism context. Cross cultural psychometric evaluation will be necessary before the instrument can be generalized to substantially different cultural or geographical settings.

Finally, subsequent studies should distinguish clearly between prospective acceptance and post experience acceptance and evaluate whether the structural relationships remain stable after actual interaction with VR based dark tourism applications.

9. Conclusion

This study developed and psychometrically evaluated a 20-item Experiential Technology Acceptance Model instrument for examining prospective acceptance of VR based dark tourism in Malaysia. The framework combines the established TAM constructs of PU and PEOU with PE and PI as experiential dimensions. PE was contextualized as reflective satisfaction to ensure conceptual sensitivity to dark tourism environments.

The instrument demonstrated strong indicator reliability, internal consistency, and convergent validity. The structural model explained 78.1% of the variance in BI and 88.6% of the variance in PI. PU significantly predicted BI, PEOU strongly predicted PU, and PE significantly predicted PI. The findings also identified important measurement limitations. HTMT values between PEOU and PE and particularly between PE and PI exceeded the

commonly applied 0.90 criterion. Consequently, the evidence does not support a claim that complete discriminant validity has been established.

The contribution of this study therefore lies not in claiming definitive validation of ETAM, but in providing an empirically evaluated foundation for continued instrument development. Future research should refine overlapping indicators, evaluate the revised measurement model using independent samples, and test the instrument following standardized exposure to operational VR experiences.

Prospective acceptance of VR-based dark tourism involves both functional and experiential perceptions. PU remains particularly relevant to BI, while reflective satisfaction contributes to anticipated immersion. Effective VR-based dark tourism experiences should therefore combine technological accessibility and interpretive usefulness with immersive design that remains historically accurate, educationally meaningful, and sensitive to the heritage being represented.

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Institutional Review Board

This study involved adult respondents aged 18 years and above who voluntarily participated in a questionnaire survey examining their perceptions and behavioral intentions toward virtual reality-based dark tourism in Malaysia. Informed consent was obtained from all participants before data collection, and participation was entirely voluntary. Respondents' anonymity and confidentiality were maintained throughout the research process. The collected data were used exclusively for academic research purposes, with appropriate measures taken to safeguard participants' privacy and ensure responsible research conduct.

AI Declaration

The author declares the use of ChatGPT (OpenAI) as an artificial intelligence-assisted tool during the preparation of this manuscript. The tool was utilized to support academic language refinement, grammatical correction, sentence restructuring, organization, and overall clarity and readability. All research concepts, methodological procedures, data collection, statistical analyses, interpretation of findings, and conclusions remain the intellectual responsibility of the author. All AI-assisted content was critically reviewed, verified, and revised by the author to ensure academic integrity, originality, and accuracy. The author assumes full responsibility for the final content of the manuscript.

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